IKONOS Radiometric Calibration Using a Low Reflectance Grass Target

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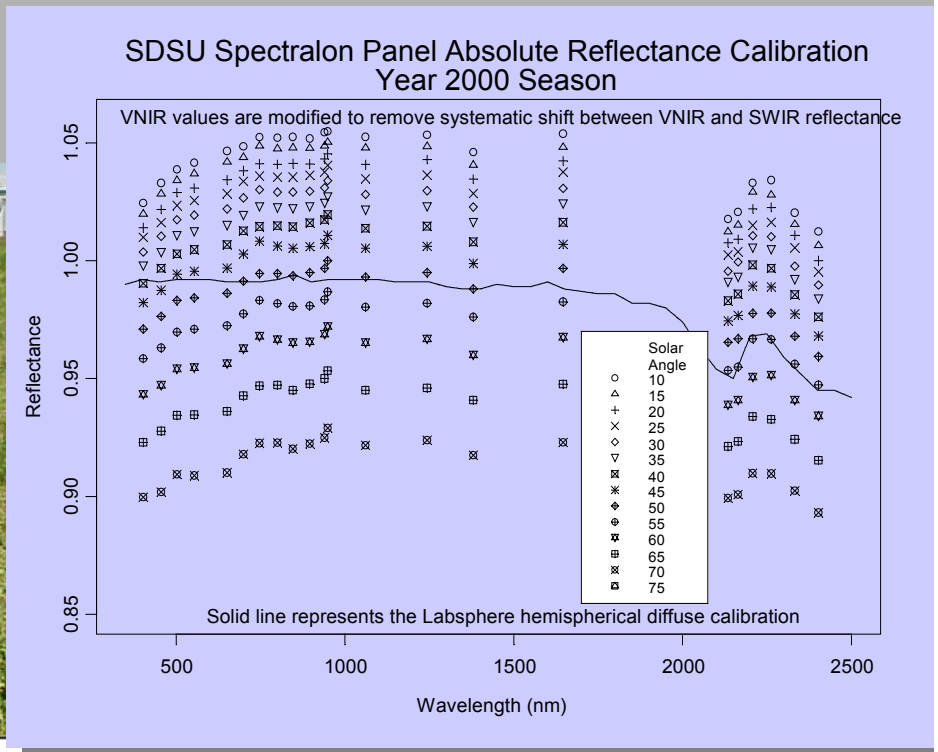
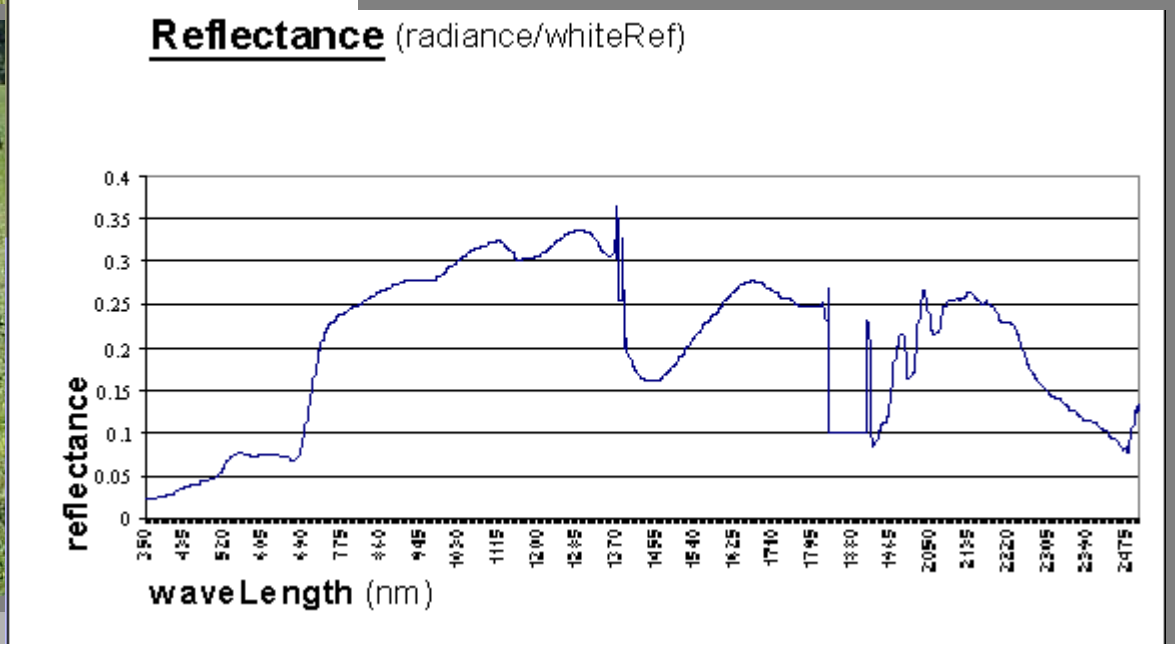
IKONOS Sensor Calibration

- Ground Truth & MODTRAN Calibration
  - Measurements of Target Surface Reflectance/Radiance
  - Upper Atmosphere & Boundary Layer Transmittance
  - Estimate At-Sensor Total Radiance and Path Radiance of Ground Target
- IKONOS Image Analysis
  - Extract Grass Target & and 0 Reflectance DN
  - Adjacency Effect Check
- IKONOS Calibration Coefficients
  - Convert MODTRAN Spectrum to In-Band Radiance
  - Derive Gain and Bias Values

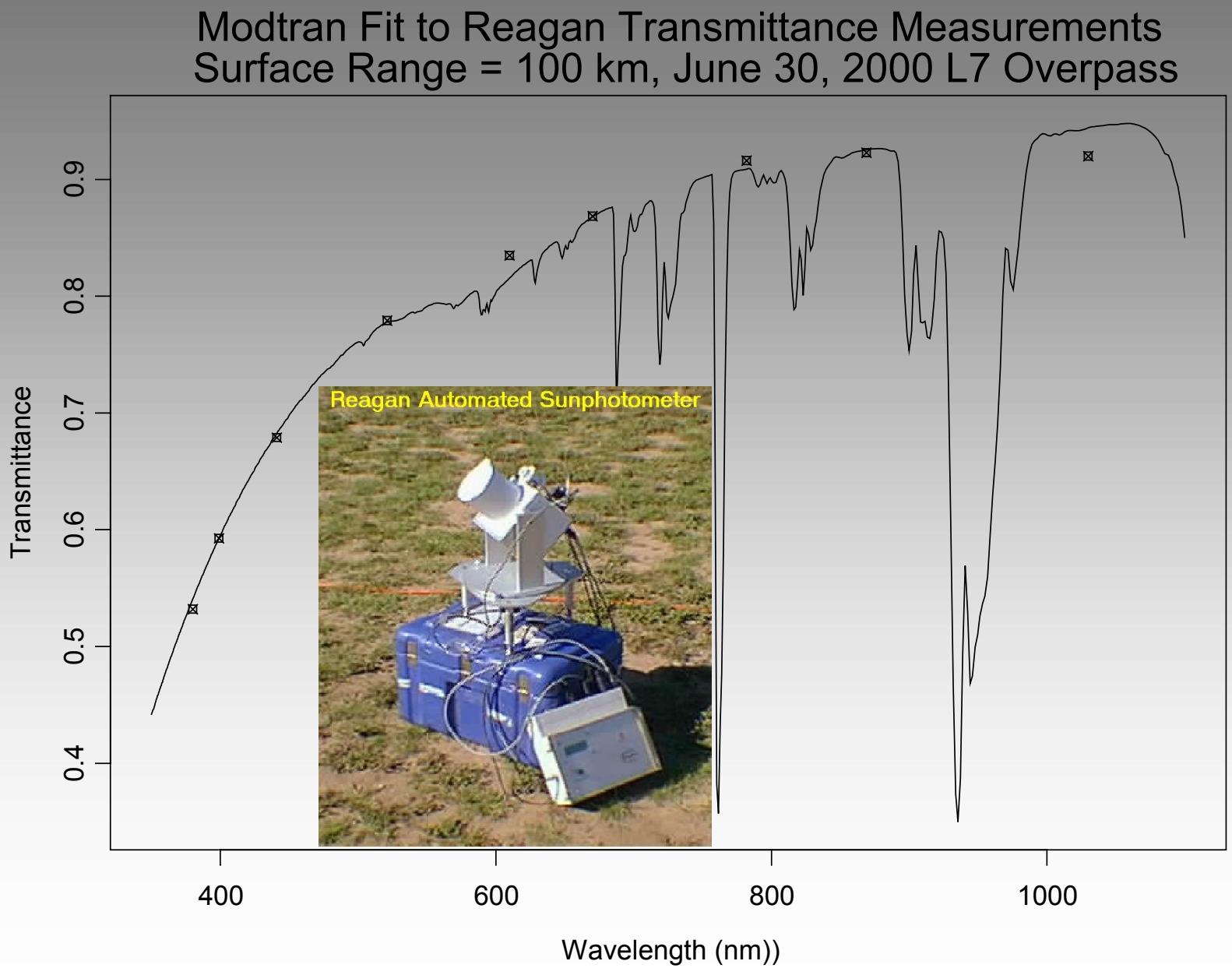
Brookings 3M Target For Radiometry and Edge Analysis

Measurement of Surface Reflectance Using an ASD Spectroradiometer



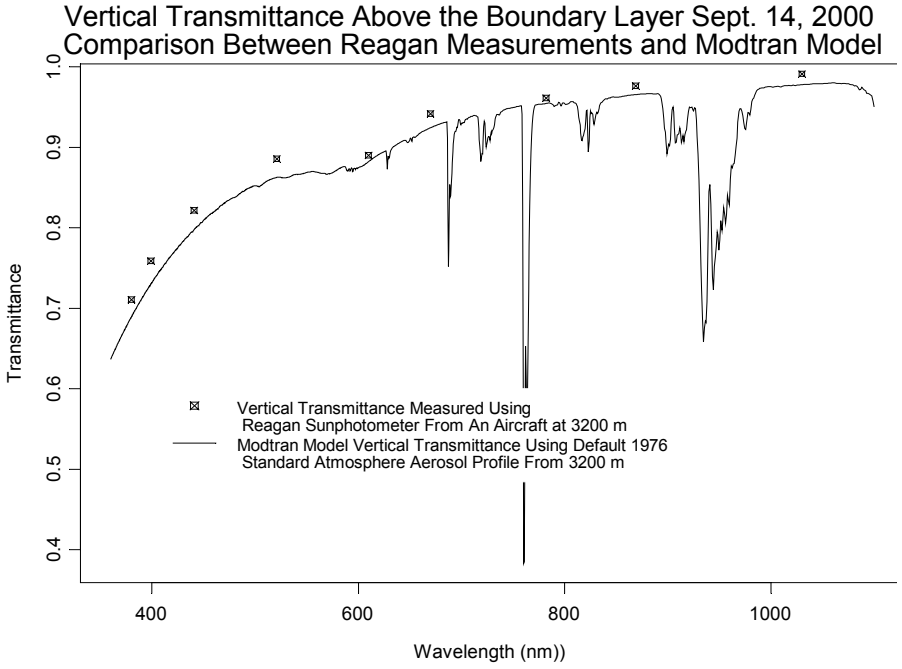


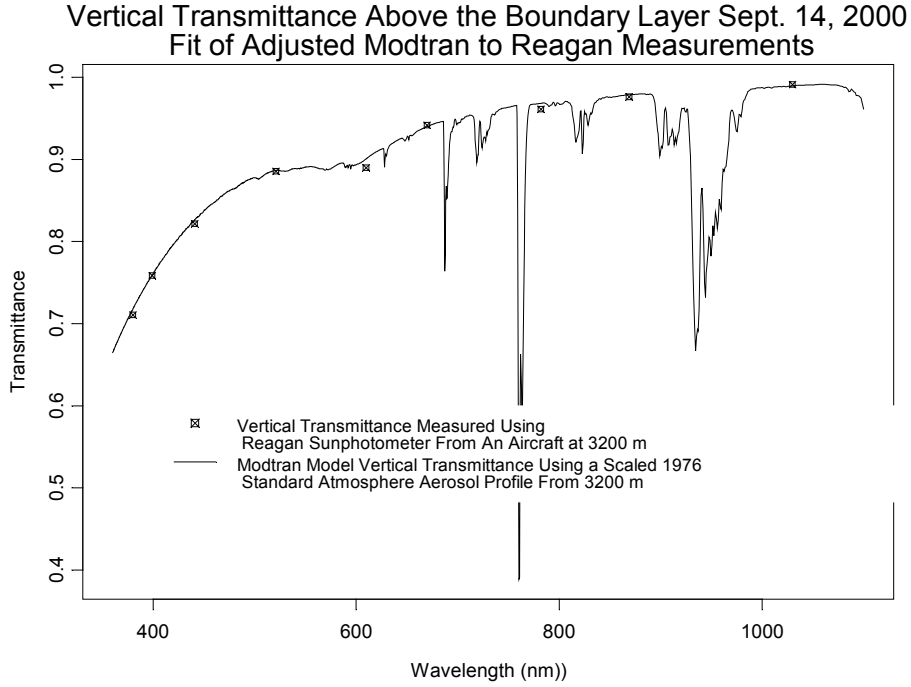
Modtran Transmittance Calibration



Evaluation of Atmospheric Transmittance Above the Boundary Layer

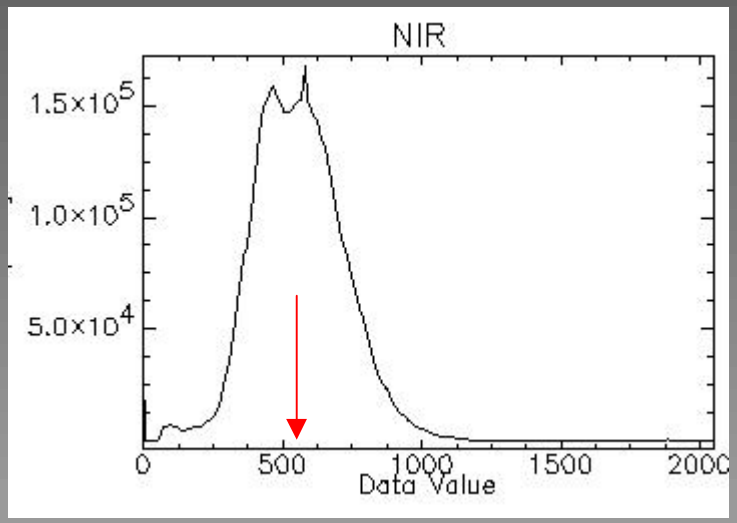
Reagan sunphotometer observations at the top of the boundary layer revealed a significantly higher transmittance than available with MODTRAN model atmospheres. The 1976 standard atmosphere was scaled to fit observations.

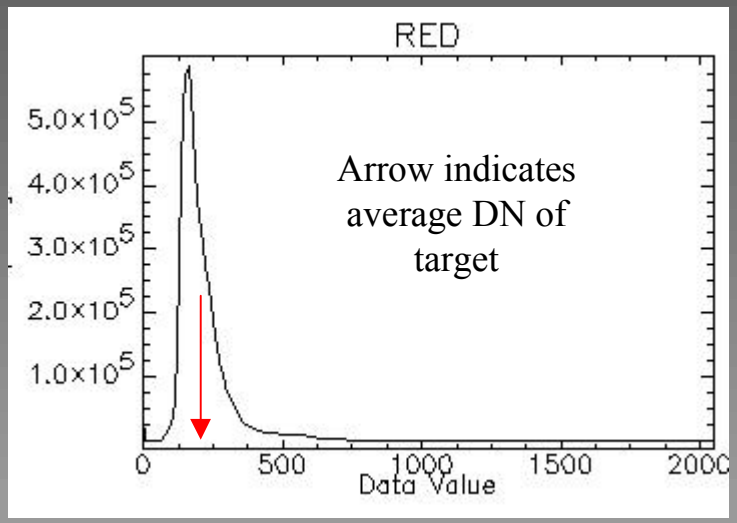


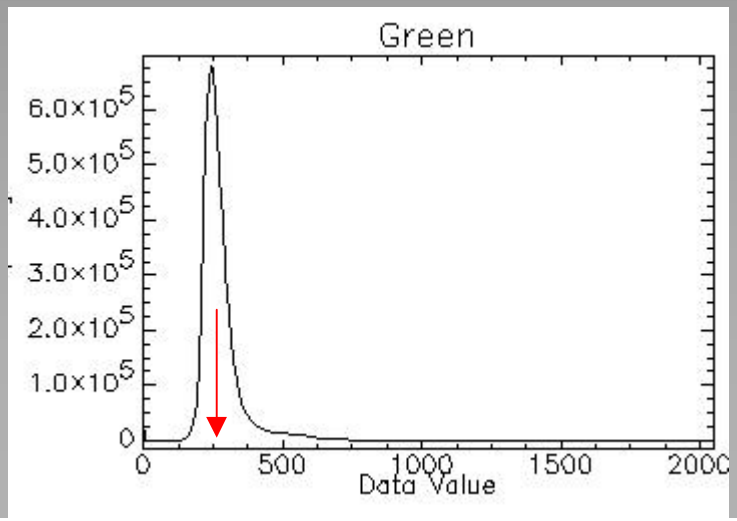


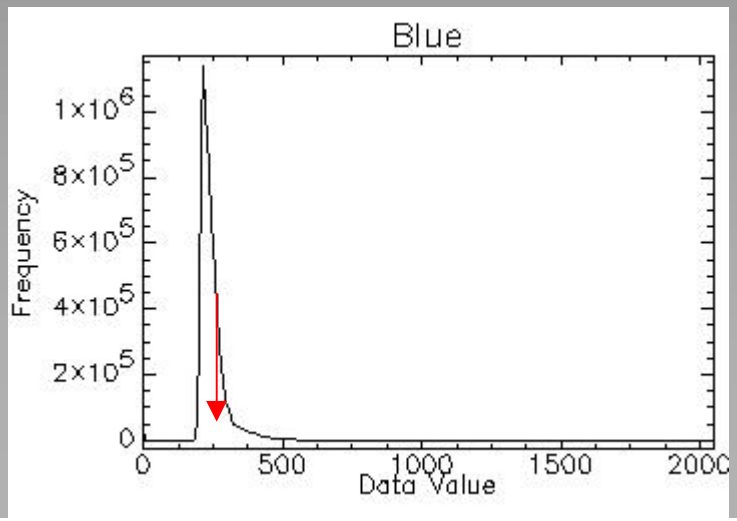
Histograms of the IKONOS image show that the average DN of the target was close to the median DN for the entire scene in each channel.

Target reflectance spectrum will also provide the background reflectance for calculation of hemispherical sky irradiance and path radiance

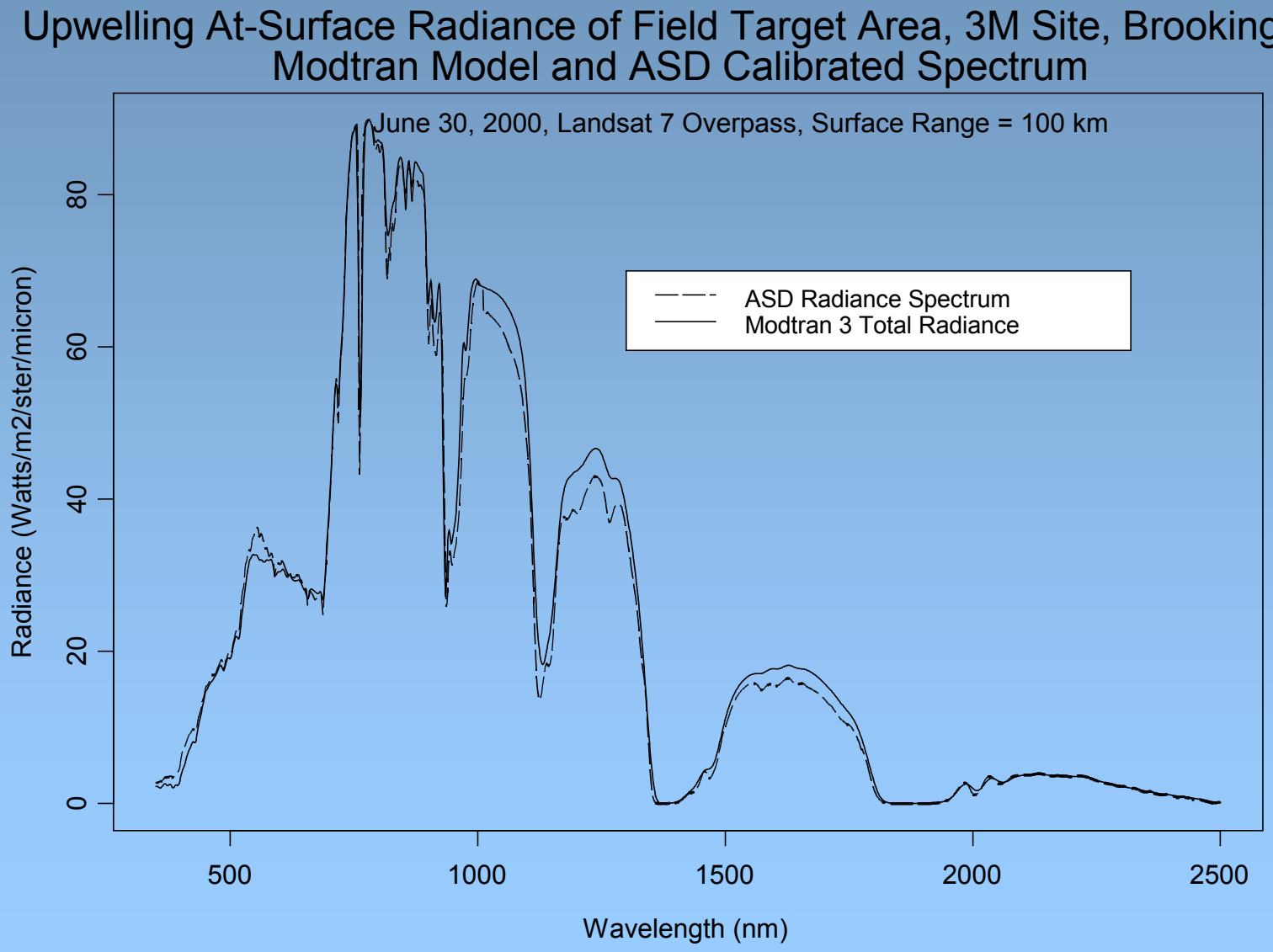




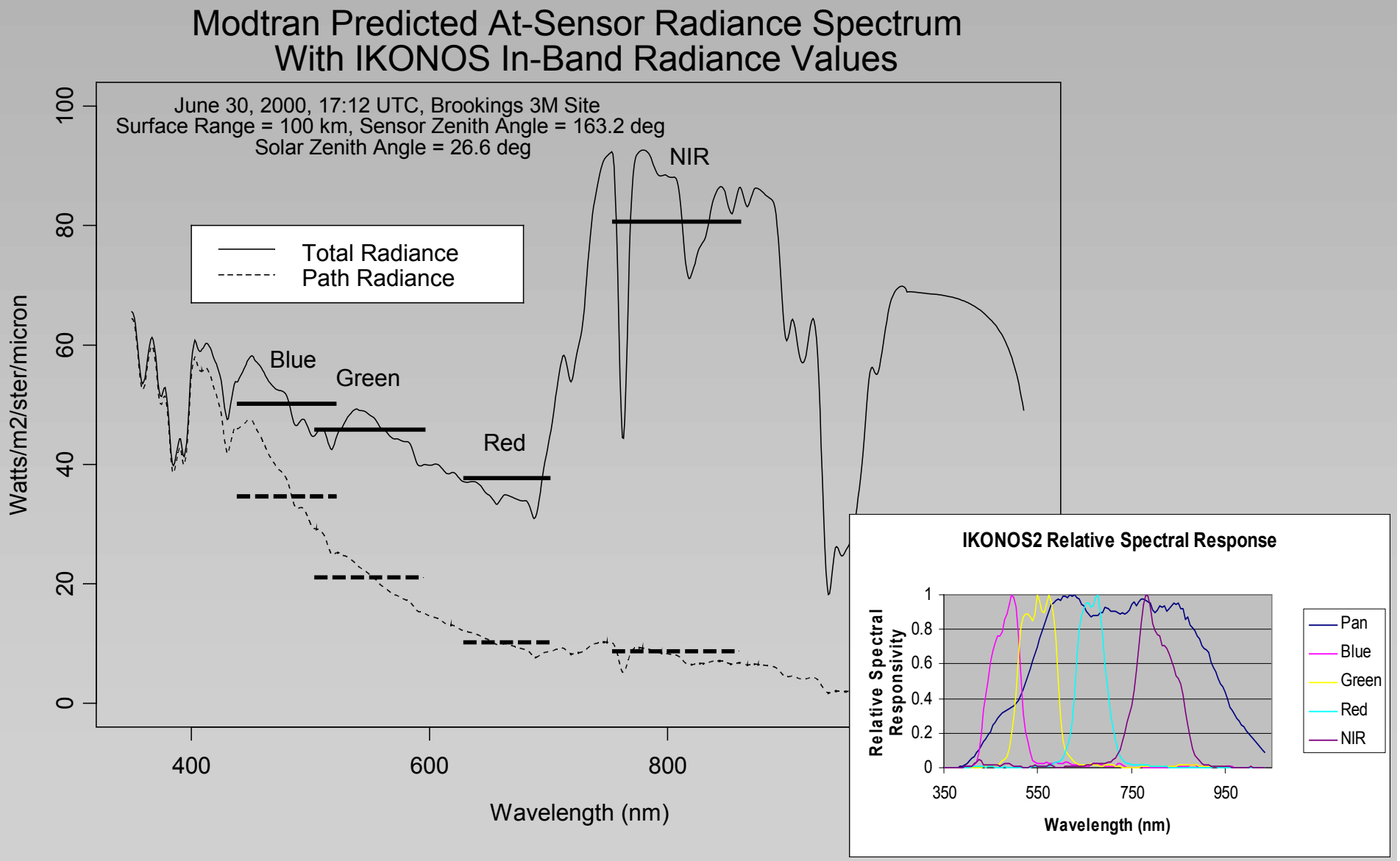




Comparison of Reflectance Based Modtran Radiance to Radiometer Measured Radiance



Modtran Model At-Sensor Radiance Spectrum

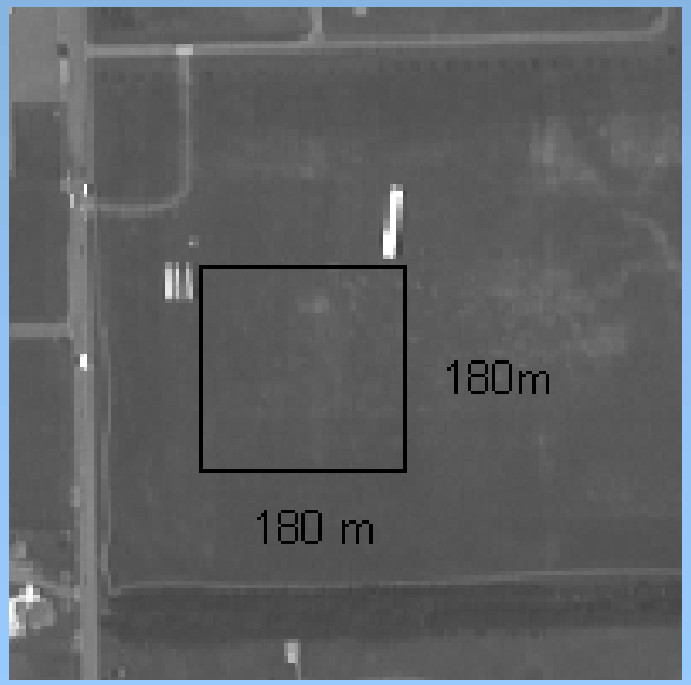


Modtran Predicted Top-of-Atmosphere Target Radiance Components at the Time of the IKONOS Overpass

IKONOS Band	Total Radiance W/m2/sr/um	Path Radiance W/m2/sr/um	In-Band Total Radiance mW/cm2/sr	In-Band Total Path Radiance mW/cm2/sr
Blue	50.14	34.66	0.369	0.255
Green	45.85	21.09	0.419	0.193
Red	37.71	10.19	0.271	0.073
NIR	80.67	8.70	0.771	0.083

Calculating Grass Target DN

- The size of test site was 180m × 180m.



- 45×45 pixels for IKONOS
- 6 × 6 pixels for Landsat 7

Grass Target (DN)

Bands	Mean	StdDev
Blue (No MTFC)	248.98	9.07
Blue	248.91	9.63
Green (No MTFC)	289.25	14.15
Green	289.26	15.11
Red (No MTFC)	225.29	24.86
Red	225.29	26.42
NIR (No MTFC)	576.80	25.06
NIR	576.81	28.88

Samples (2036, 2080)
Lines (1869,1913)

Estimated Detector Gain Assuming Bias Removed

- Detector Gain = Image DN/TOA Target Radiance
- Gain Units = DN/(mW/cm2/sr)

IKONOS Band	SDSU Gain 6/30/00	Space Imaging Gain	Relative Difference
Blue	675	637	5.8%
Green	690	573	18.5%
Red	831	663	22.5%
NIR	748	503	39.2%

Evaluating Sensor Bias

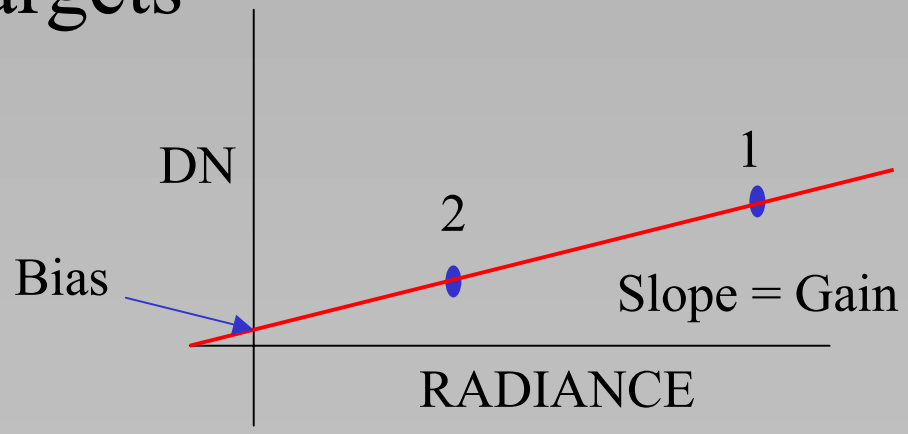
- Detector Response
  - Digital Number = Gain × Radiance + Bias
- Coefficients derived from a two point calibration

1-Brookings Ground Target

(Target Radiance + Path Radiance, DN)$_1$

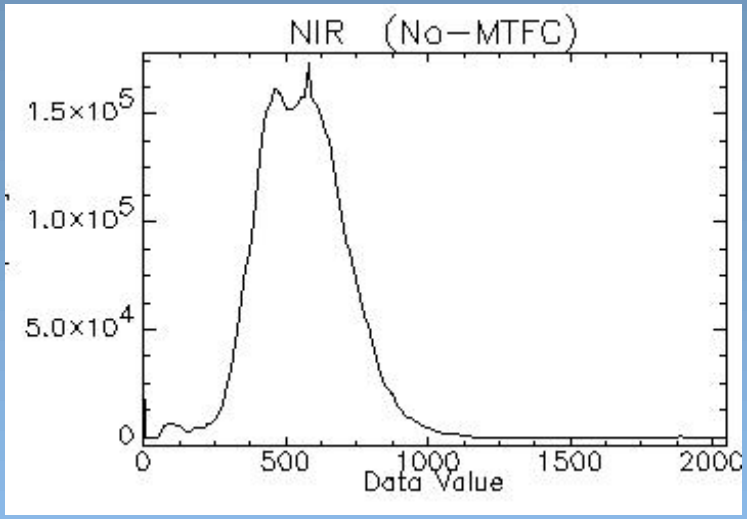
2-Zero Reflectance Targets

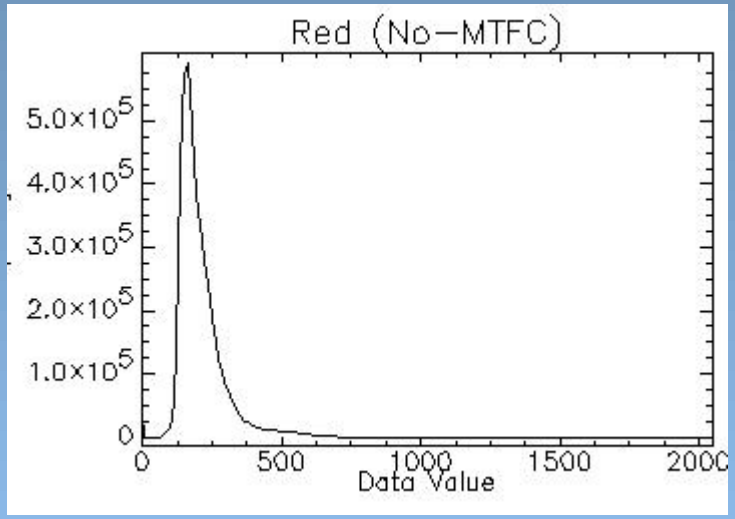
(Path radiance, DN)$_2$

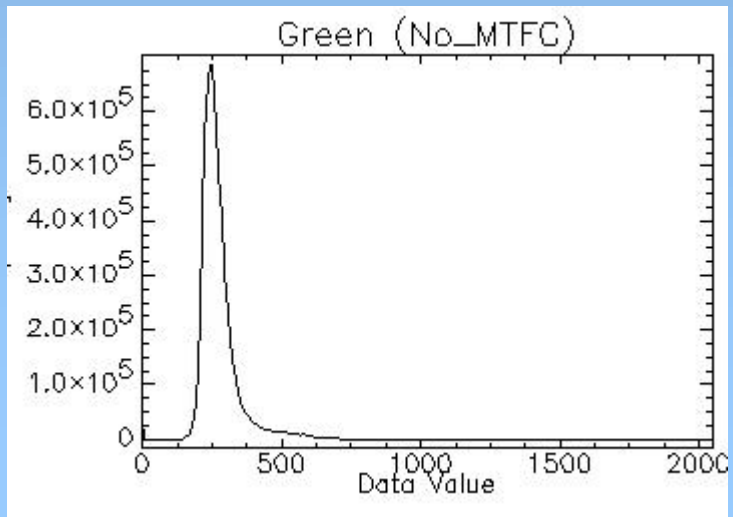


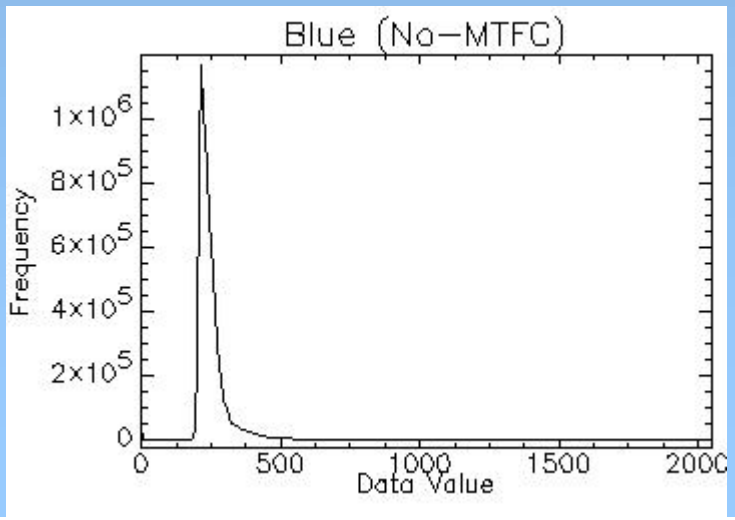
Surface Feature With Smallest DN Was Assumed To Have "Zero Reflectance"

Identified from histogram of the entire IKONOS scene

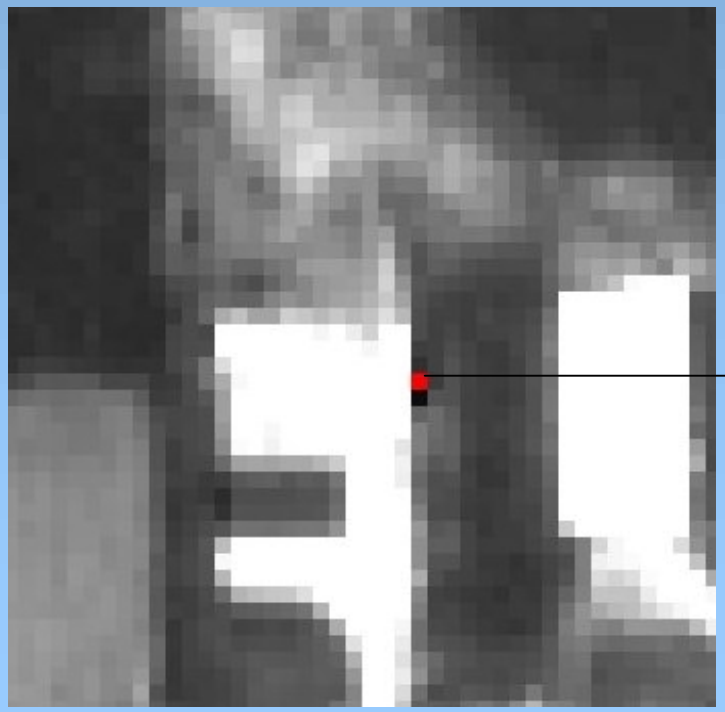








Finding appropriate “zero reflectance” targets was done with MTFC off

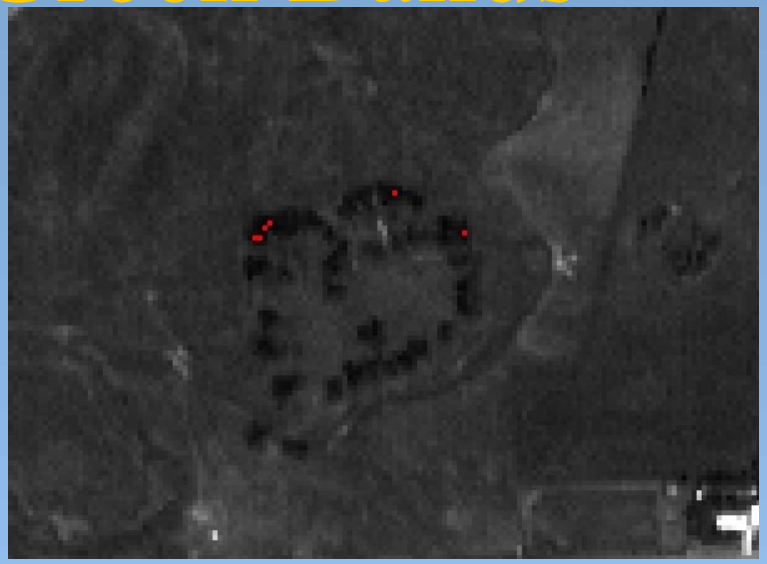


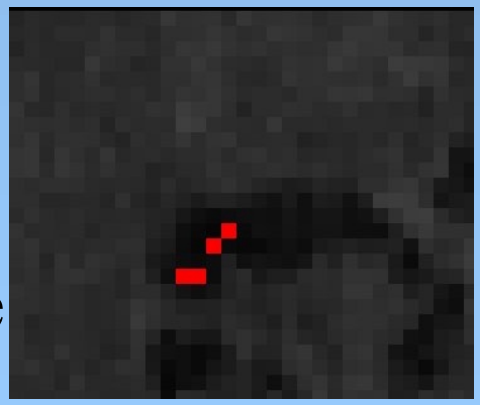
(1905,886)
DN = 0 with MTFC on
DN=176 with No MTFC

Choosing "Zero Reflectance" Targets in the Red and NIR Bands

- Lakes or ponds produced the darkest pixels.
- Minimum DN of area in red provided path radiance DN.

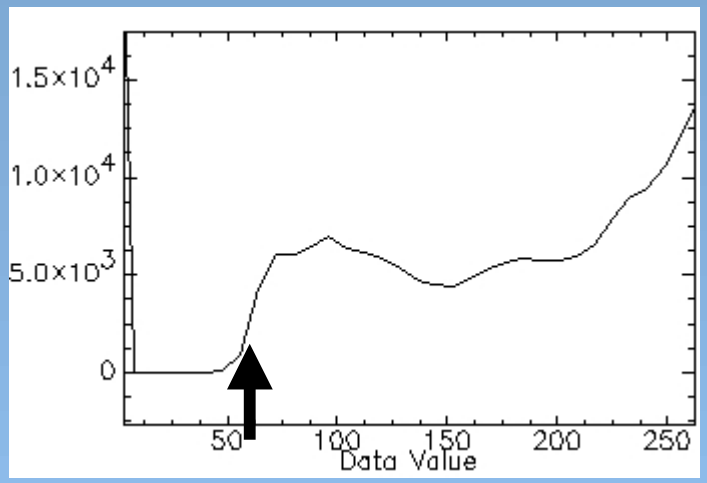
Choosing "Zero Reflectance" Targets in the Blue and Green Bands



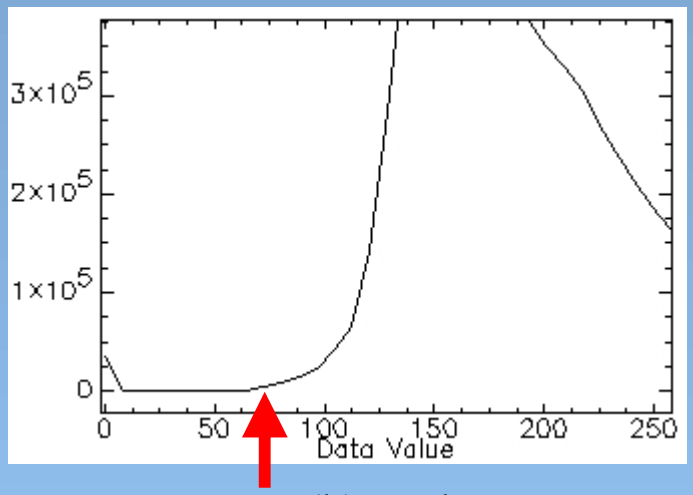


- Shadows in tree stands produced the minimum DN's.
- Smallest DN => Path Radiance DN

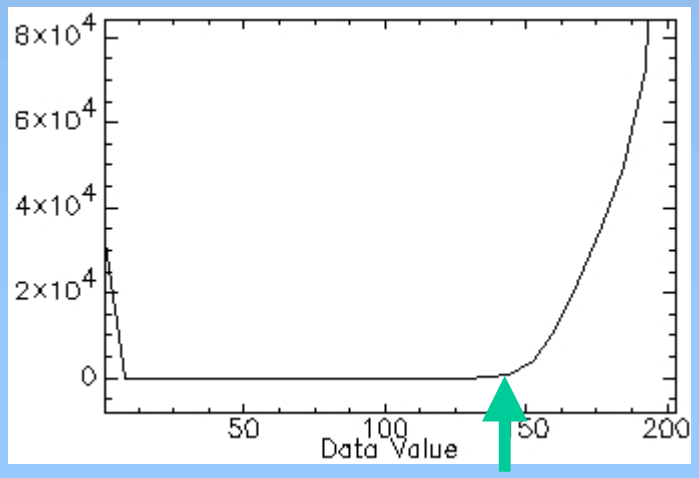
Assumed Path Radiance DN's Located On Histogram Plots



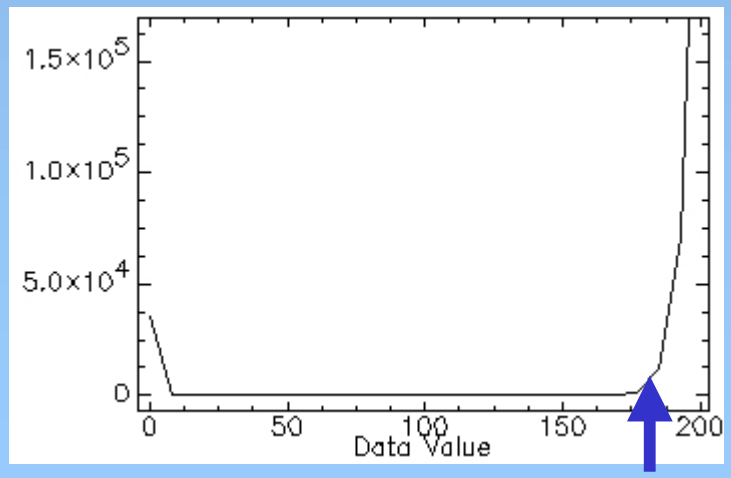
(a) NIR



(b) Red



(c) Green



(d) Blue

“Zero Reflectance” Target DN’s

Bands	DN
Blue (No MTFC)	184
Blue	182
Green (No MTFC)	149
Green	142
Red (No MTFC)	71
Red	69
NIR (No MTFC)	60
NIR	58

Set Dark Target Radiance = Path Radiance

Ground calibration

- Radiances for bands were calibrated on June 30.

Bands	Radiance
NIR	80.67
Red	37.71
Green	45.85
Blue	50.14

Radiance
$W/m^2/sr/um$

Estimated Detector Gain

- Gain equation is

$$Detector\ gain = \frac{DN - bias}{radiance}$$

Bands	Gain DN/mW/cm2/sr	Bias DN/mW/cm2/sr	SI Gain DN/mW/cm2/sr	Gain Rel. Diff.
Blue (No MTFC)	570	38.6	637	-11.1%
Blue	588	32.2	637	-8.0%
Green (No MTFC)	619	29.6	573	7.7%
Green	650	16.6	573	12.6%
Red (No MTFC)	780	13.9	663	16.6%
Red	790	11.1	663	17.6%
NIR (No MTFC)	752	-2.5	503	39.7%
NIR	755	-4.7	503	40.1%

Conclusion

- SDSU gain measurements show a difference with Space Imaging values that increases with increasing wavelength.
- Agreement exists within uncertainties in the blue channel and possibly green but not red and NIR
- Possible residual bias in blue and green channels